An important advantage, which can be achieved with the method according to the invention, lies in

that, instead of possibly faulty information about the interference to be expected, the information about the interference is obtained from the actual received signal and is thus continuously updated. A further advantage lies in the possibility of obtaining information both on the spatial correlation characteristics of the interference and on the temporal correlation characteristics of the interference.

This information can be used either directly to suppress interference when estimating the user signals from the received signals. Alternatively, information about the directions of incidence of the interference at the receiver can be obtained from the information about the spatial correlation characteristics of the interference, depending on the signal processing algorithm. In the case of multi-antenna receivers, the information about the directions of incidence of the interference at the receiver or, respectively, about the spatial correlation characteristics of the interference can be used for generating directional patterns. The patterns, of which selectively have less gain in those directions from which strong interference signals arrive at the receiver, cause the ratio between useful power and interference power at the receiver end to be maximized.

The previous considerations relate to the receiver end. In duplex systems, each receiver is paired with a transmitter. If multi-antenna systems are used for receiving and transmitting, the information about the received interference (obtained in accordance with the method explained above) can be used for advantageously driving the antennas in the transmitting case. The basic idea of this is that sending one's own signals into the directions from which strong interference signals are incident tends to produce strong interference in other receivers. When a number of antennas is used, therefore, the knowledge of the main directions of interference at the receiver end can be generally used, independently of the transmission system considered, to radiate as little power of the transmitted signal as possible in the directions of the main interference source and thus to reduce interference seen throughout the system.

As an exemplary embodiment, one possible implementation of the method according to the invention for obtaining information with respect to the interference is presented with reference to the discrete-time model

of the uplink of a TD-CDMA mobile radio system in the text which follows. Moreover, it is shown here how the information obtained can be used for improving the quality of transmission. Use in other transmission systems is also included in the scope of the invention.

The corresponding receiving system is shown in figure 1. It is assumed that K mobile subscribers are simultaneously transmitting in the same frequency band and time slot and the subscriber signals are separated by subscriber-specific CDMA codes.

The transmitted bursts include two data blocks and a midamble arranged between them which provides for the channel estimate at the receiver end. In the text which follows, the first data block of a burst will be considered in the description of the data detection. A corresponding observation would apply to the second data block. According to R. Schmalenberger, J.J. Blanz: Multi antenna C/I balancing in the downlink of digital cellular mobile radio systems. Proc. IEEE Vehicular Technology Conference (VTC'97), Phoenix, 1997, p. 607 to 611, a system matrix A can be set up which includes both the K * Ka channel impulse responses of the K subscribers to the Ka receiving antennas and the type of signal generation at the transmitter end. Together with the total data vector d, which includes the data blocks of the K subscribers, and a total interference vector n, the total received-signal vector e

$$e = Ad + n \qquad (12)$$

is obtained. e includes samples of the received signals at all Ka antennas which are based on the first data block of a transmitted burst. Firstly, a channel estimator 1 forms a channel estimate and a common detector 2 performs joint detection of the subscriber signals R. Schmalenberger, J.J. Blanz: Multi antenna C/I balancing in the downlink of digital cellular mobile radio systems. Proc. IEEE Vehicular Technology Conference (VTC'97), Phoenix, 1997, p. 607 to 611, by the generally disturbed received signals e. In TD-CDMA systems, algorithms which can include the knowledge of the entire covariance matrix according to (8) are used for the joint data estimate of subscribers.

One example of such algorithms is the zero-forcing algorithm. In one- or multi-antenna receivers in systems according to the prior art, it is assumed that the temporal covariance matrix R_t can be determined directly from the spectral shape of the transmitted signals. In the text which follows, this covariance matrix is designated by R_t. This matrix R_t is taken into consideration in the data detection, even though the actual temporal correlations of the interference signals at the receiving site may deviate from the assumed temporal correlations due to multi-path propagation of the interference from an interference source.

In the case of multi-antenna receivers in systems according to the prior art, the spatial correlations of the interference are not taken into consideration in the detection of the data and/or in the channel estimate, i.e. the covariance matrix R_s is replaced by the Ka x Ka unity matrix $I^{(Ka)}$. Thus, there is no optimum data detection in the sense of the zero-forcing algorithm in systems according to the prior art. The method according to the invention can be used for

improving the data estimate and the channel estimate by prior estimating of the covariance matrix R_n of the interference due to the estimating of the received interference at each antenna, as shown in figure 1.

To estimate the interference, a conventional data detection is first performed for a number of received bursts, using the matrix

$$\underline{R}_n = I^{(Ka)} \otimes \underline{\tilde{R}}_t \qquad (13)$$

for the covariance matrix R_n according to (8), using the matrix $\underline{\tilde{R}}_t$. This provides an estimate

$$\underline{\hat{d}} = \left(\underline{\hat{A}}^{*T} \underline{R}_n^{-1} \underline{\hat{A}}\right)^{-1} \underline{\hat{A}}^{*T} \underline{R}_n^{-1} \underline{e} \qquad (14)$$

of the transmitted data which can be used for the approximate reconstruction of the received signal based on the user signals

$$\underline{\hat{e}}_d = \underline{\hat{A}} \cdot \underline{\hat{d}} \qquad (15)$$

by the system matrix $\underline{\hat{A}}$ which includes the information about the estimated K * Ka channel impulse responses. The reconstruction $\underline{\hat{e}}_d$ is performed in a signal reconstructor 5. Units 3 and 4 (FEC decoder and FEC coder) can be arranged between units 2 and 5. Unit 3 performs FEC decoding at the receiver end for the case in which FEC coding is taken into consideration in the signal processing at the transmitter end. In unit 4, a corresponding FEC coding of the estimated data takes place to obtain correct signal reconstruction. Subtracting the reconstructed received signal $\underline{\hat{e}}_d$ according to (15) from the actual received signal e according to (12) makes it possible to determine an estimate

$$\underline{\hat{n}} = \underline{e} \cdot \underline{\hat{e}}_d \qquad (16)$$

a12

for the total interference factor n according to (7). From the estimates of the interference signals at the individual antennas, which were thus obtained, both the spatial correlation characteristics of the interference, see (11), and the temporal correlation characteristics of the interference, see (5), and thus the covariance matrix $\underline{\hat{R}}_n$ of the interference according to (6) can be estimated in an estimating unit 6.

Taking into consideration the estimated covariance matrix, the signals received at the individual antennas can be subjected both to an improved channel estimate, if such a one is required, and to an improved data estimate R_n according to (13) being replaced by $\underline{\hat{R}}_n$.

The procedure described up to here can be iteratively continued. Assuming that the interference scenario, and thus also the correlation characteristics of the interference, do not or do not significantly change during the provided period of estimating the matrix and in the subsequent period which is provided for estimating new data, the estimated covariance matrix $\underline{\hat{R}}_n$ can be used for estimating new data in order to achieve an improvement in the data estimate.

--WHAT IS CLAIMED IS--.